FERNALD ENVIRONMENTAL MANAGEMENT PROJECT SITE DEER MANAGEMENT PLAN

FERNALD ENVIRONMENTAL MANAGEMENT PROJECT
FERNALD, OHIO

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U.S. DEPARTMENT OF ENERGY
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A1PI	Area 1, Phase I
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A8PII	Area 8, Phase II
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980
DOE	U.S. Department of Energy
FEMP	Fernald Environmental Management Project

1.0 INTRODUCTION

The 1,050-acre Fernald Environmental Management Project (FEMP) is undergoing large-scale environmental remediation pursuant to the Comprehensive Environmental Response, Compensation, and Liability Act (CERCLA). To address potential natural resource damage liability under CERCLA, the U.S. Department of Energy (DOE) is committed to ecological restoration of most of the site following remediation. The white-tail deer (*Odocoileus virginianus*) represents one of the greatest threats to ecological restoration projects at the FEMP. This management plan considers deer management within the context of ecological restoration. First, it summarizes the status of deer impacts and control measures currently in place at the FEMP. Second, it provides recommendations for minimizing impacts to future ecological restoration efforts on the FEMP property.

1.1 BACKGROUND

DOE and the other CERCLA-defined natural resource trustees have agreed to address natural resource damage liability through a series of on-property ecological restoration projects. These projects are planned in a phased approach, following site remediation, through 2009. The habitats to be restored include forest and riparian communities, prairies and savannas, and wetlands. Site restoration will require extensive soil excavation and regrading, planting large quantities of native trees and shrubs, and reseeding with native grasses and forbs. Approximately 880 acres will be restored by 2009.

Ecological Restoration of the FEMP was initiated in 1998 with the construction of an aesthetic barrier along Willey Road, which is the southern boundary of the site. A publicly-accessible Ecological Restoration Park was also constructed on the western portion of the site. In 1999, the Area 1, Phase I (A1PI) Wetland Mitigation Project was created in the northeast portion of the site. The Area 8, Phase II (A8PII) Forest Demonstration Project was implemented on the northwest corner of the FEMP. To date, approximately 45 acres of the FEMP site have undergone some form of ecological restoration.

Deer browsing and rubbing have impacted every restoration project at the FEMP. Fluor Fernald, Inc. has collected data to monitor the impact that white-tail deer have on restored areas of the FEMP. Section 2.0 of this plan summarizes the current status of deer at the FEMP, and documents the extent of deer damage observed to date. A number of measures have been implemented to reduce the impact of the deer on planted vegetation within restoration projects. Section 3.0 discusses these various control options, such

as repellents, tubing, and fencing. Despite control measures, trees and shrubs planted in restored areas continue to be impacted through browsing and rubbing. Section 4.0 discusses options for future control of deer impacts, and Section 5.0 provides a path forward for minimizing deer damage in order to successfully implement ecological restoration projects at the FEMP.

1.2 DEER IMPACTS AND ECOLOGICAL RESTORATION

Numerous studies have documented the impacts of deer browsing on forest ecosystems (Alverson 1988, Heinen 1990, Tierson 1966). Effects of deer populations on forest habitats range from decreases in herbaceous vegetation diversity and songbird abundance to total denudation of woody and herbaceous understory (DeColesta 1998). Deer browsing is also a limiting factor in clear-cut forest regeneration (Marquis 1978). In addition, Inouye (1994) found that deer browsing contributed to the very slow succession of a sand plain old field in Minnesota. Similar impacts due to browsing, where deer significantly limit the growth of herbaceous vegetation and woody shrubs and seedlings, have been observed in both existing and restored habitats at the FEMP. Impacts to restored areas are summarized in Section 2.2 of this plan.

The biological carrying capacity is the number of deer that an area can sustain without degradation of the deer herd or the ecosystem. When the biological carrying capacity is exceeded, impacts to deer and their habitat result. An acceptable population density of deer within a given area varies. Several researchers have found ecological impacts when densities approximate 10 deer per square mile (Alverson 1988, DeColesta 1998). In agricultural areas (such as the predominant land use surrounding the FEMP), where abundant crops serve as food sources, biologically acceptable densities are probably higher (Tonkovich 2001). The existing conditions at the FEMP, where the quality and quantity of cover is good and abundant food sources are nearby, probably results in a higher biological carrying capacity. However, as detailed in Section 2.2, the historical biological carrying capacity of the site may be undergoing a change, as more and more of the FEMP is ecologically restored with young herbaceous and woody vegetation.

The concept of biological carrying capacity is, theoretically, free from subjective influences of land use priorities, species preferences, etc. It can be measured empirically and is simply used as an analysis of population growth for a given species (Brower 1990). However, when human priorities and preferences have a bearing on the decision making process for ecosystem management, the concept of cultural

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carrying capacity needs to be utilized. Cultural carrying capacity is defined as the maximum number of deer that can coexist compatibly with local human populations in a given area (Maryland Department of Natural Resources 1998), which involves considering the priorities placed on natural resources by humans. For instance, if maintenance of healthy deer population for recreation and aesthetics is a priority, then impacts to herbaceous and woody understory is not a concern, and a higher density of deer would be tolerated and even encouraged. On the other hand, if the presence of woodland wildflowers is a priority, then much lower densities of deer would be tolerated. The Maryland Department of Natural Resources (1998) points out that even very low densities of deer can exceed the cultural carrying capacity of an area. For instance, the presence of a single deer near an airport runway is too many deer.

In the context of ecological restoration at the FEMP, some would argue that the site would be able to support a higher density of deer, especially as forest restoration progresses. Others could contend that ecological restoration introduces much more sensitive habitats, thereby reducing the density threshold where ecological impacts are evident. Obviously, the appropriate cultural carrying capacity at the FEMP is open to debate. However, from a trusteeship perspective, DOE, the other natural resource trustees, and community stakeholders have placed a priority on restoration of ecosystems native to southwest Ohio. In addition, DOE must ensure the success of site ecological restoration in order to adequately compensate for natural resource damage liability. Because of this, the cultural carrying capacity of deer at the FEMP may actually be much lower than the biological carrying capacity, since young, recently transplanted vegetation are extremely susceptible to deer browsing and rubbing impacts.

It is important to note that the ability to maintain very low deer population densities at the FEMP (i.e., 10 deer per square mile) is unrealistic, due to the status of the deer population in the surrounding areas of Hamilton and Butler Counties. FEMP deer are not limited by property boundaries, and many site deer are considered transient. However, given the priorities placed on successful ecological restoration by DOE and the natural resource trustees, impacts to existing ecological restoration projects are sufficient to warrant the control measures and recommendations put forth in this plan.

2.0 STATUS OF FEMP DEER

This section summarizes the extent of information collected regarding deer and their effect on ecological restoration at the FEMP.

2.1 CURRENT POPULATION ESTIMATE

In 1999, DOE took the lead to assess the deer population at the site and began working with local deer experts to survey the status of the deer population. Surveys of deer activity in perimeter areas of the site took place throughout 1999 and 2000, resulting in an estimate that the deer population at the FEMP was between 80 and 100 individuals on the 1,050-acre site. The FEMP covers approximately 1.64 square miles. This equates to an estimated density of 50 to 60 deer per square mile.

2.2 EXTENT OF DAMAGE TO RESTORED AREAS

Deer browsing and rubbing have proven to be a major factor in the loss of planted stock following ecological restoration. The extent of deer damage for completed restoration projects is summarized below and on Table 1.

2.2.1 Area 8, Phase I Revegetation Research Plots

Three-hundred (300) sapling trees and 2,400 seedlings were planted in Spring 1999 as part of research conducted by Miami University. Approximately 117 (39 persent) of the saplings planted were damaged by rubbing in the fall of 1999. Browsing was observed on about 60 (20 percent) of the saplings as well. The browsing was concentrated on chinquapin oak, which branched low and was easily accessible to deer. Ohio buckeye was not browsed, even though it also branched low and was accessible. Foliage from all other saplings planted were out of reach for deer. Browsing of seedlings was minimal. Researchers conjectured that seedlings remained hidden from deer by tall pasture grasses present in the test plots.

Recorded damage was reduced in 2000 (13 percent). However, fieldwork was conducted before the main rut season, when more damage would take place. Once rub damage was observed by site personnel later in Fall 2000, tubes were installed on all saplings. Data collected in 2001 revealed that rub damage was significant in Fall 2000, as the percentage of damaged trees jumped to 31 percent. Researchers noted that the tubes did appear to be working, though, since only three of the trees damaged were from fresh

rubs. Most of the damage occurred in 2000, after survey work was completed but before tubes were installed. Browsing in both 2000 and 2001 continued to be associated mainly with chinquapin oak.

2.2.2 Area 8, Phase I Ecological Restoration Park

Over 550 sapling trees and shrubs were planted in the Area 8, Phase I (A8PI) Ecological Restoration Park in Fall 1998. Observations of planted stock in 2000 indicated that 16 trees (6 percent) were rubbed and 12 (4 percent) were destroyed by deer. The majority of the damage was concentrated outside of the publicly-accessible fenced area, along an existing tree line. These trees were protected with plastic tubing when they were planted. The majority of damage consisted of broken limbs above the tubing. Buckeye, cottonwood, red maple, and sycamore trees constitute most of the damaged species. Several red cedars were also destroyed (which cannot be protected with tubing). Since construction, taste repellents have been consistently applied to shrubs and small trees within the Ecological Restoration Park. Some browsing has been observed from 1999 to 2001, but damage has been minimal.

2.2.3 Area 2, Phase I Bioengineering Project

In September 1998, 31 sapling trees were planted along the southern bank of Paddys Run within the Area 2, Phase I (A2PI) Bioengineering Project. A survey conducted in October 1999 concluded that 18 (58 percent) of the trees were rubbed, and three (10 percent) were destroyed. Almost all of the deciduous trees were rubbed (buckeye, cottonwood, red maple, and sycamore). Plastic tubing was not on the trees when most of the damage occurred in 1999. Tubing was installed later in 1999, and most of the trees have recovered. Several saplings have outgrown the tubing. All of the planted saplings branched above the browse line, so browsing has not been a factor in this project.

2.2.4 Area 1, Phase II Aesthetic Barrier Project

In Fall 1998, 62 deciduous trees and 61 coniferous trees were planted in the Area 1, Phase II (A1PII) Aesthetic Barrier Project. In October 2000, a survey showed 33 (54 percent) of these species have been rubbed, notably redbud, red oak, red maple, and tulip poplar. Plastic tubing was installed after these rubs were observed, and most of the trees have recovered.

2.2.5 Area 1, Phase I Wetland Mitigation Project

Approximately 3,000 trees and shrubs have been planted from 1999 through 2001 as part of the A1PI Wetland Mitigation Project. Several deer damage surveys and mortality counts have been conducted on

this project. Results from the first survey, conducted in Fall 1999, revealed that 39 percent of the wetland plants planted in Spring 1999 were damaged by deer browsing. An additional 17 percent were destroyed. Also, 4 percent of the trees planted showed signs of rubbing. Sapling trees were subsequently protected with tree tubing prior to the Fall 2000 rut season. Subsequent mortality surveys within A1PI have demonstrated that about 33 percent of all planted stock was impacted by deer. Over 5 percent of tree and shrub mortality within the Wetland Mitigation Project was due to browsing and/or rubbing pressure. Table 2 summarizes deer damage and mortality by individual planting patch, while Table 3 lists the extent of deer damage by species within A1PI. Significant browsing impacts have been observed within the Wetland Mitigation Project despite repeated applications of taste repellents.

2.2.6 Area 8, Phase II Forest Demonstration Project

Over 1,700 sapling trees and shrubs have been planted within A8PII in 2000. Since then, several deer impact and mortality surveys have been conducted. According to a survey conducted in Fall 2000, approximately 7 percent of the planted trees were damaged, and 2 percent were destroyed. The majority of the rubbing occurred in the southeast portion of the project area. Tree tubes were installed prior to the fall rut season in 2000. In response to the Fall 2000 rub pressure, DOE initiated the installation of odor-repellent garlic sticks on all saplings and shrubs within A8PII.

Mortality counts in summer 2001 reaffirmed the impacts to planted stock by deer rubbing. Four of the five forest planting patches that did not meet 80 percent survival requirements are located in the southeastern portion of the project area, where the 2000 deer rub pressure was greatest. Table 4 illustrates the extent of deer damage recorded by planting patch, while Table 5 lists the extent of deer damage by species in 2001. Shrubs have been consistently sprayed with taste repellents since their installation in Fall 2000. Some browsing pressure is evident, but impacts have been minimal.

2.3 DISCUSSION

Based on the deer damage data collected onsite from 1999 to 2001, it is difficult to infer any species specific trends of deer browsing or rubbing preference. As Table 3 shows, 70 different species of shrubs and trees were damaged by deer within the A1PI Wetland Mitigation Project. A8PII showed a similar variety of impact, as 32 out of 39 total species planted were impacted by deer (Table 5). Instead, impacts seem to be correlated to specific areas of pressure. The majority of damage in A1PI has been concentrated in the southern and northern portions of the project (Figure 1). Likewise, in A8PII, most of

the deer impacts occurred in the southeastern portion of the project area (Figure 2). This area is bounded by a dense overstory, a rarely-used elevated railroad track, and a small hill that provides cover from the road.

An additional factor to consider when discussing deer control options is the cost of deer damage. The economic impact from site impacts is substantial. The cost of plant deaths in A1PI attributed to deer damage is about $6,240 from 2000 to 2001 alone. This figure only includes 4 percent of the total deer damage, since it does not include deer damage in species that are still alive.

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3.0 SUMMARY OF CURRENT CONTROL EFFORTS

As described in the above summaries of restoration projects across the FEMP site, control efforts have focused on two approaches: repellents and protective tubing. During the initial design phases on the A1PI Wetland Mitigation Project, recommendations were made that fencing be used as a control measure around the entire project area. DOE quickly determined that fencing around the entire wetland mitigation project would not be practical or acceptable with respect to the area aesthetics. As a result, DOE decided to apply deer repellents directly to trees and shrubs in order to minimize deer damage to planted vegetation. These approaches have had in varying degrees of success. Tree tubes have been used to protect sapling trees from rubbing pressure since construction of the Ecological Restoration Park. This section summarizes the extent of protection afforded by these two options.

3.1 REPELLENTS

Taste repellents have been utilized on virtually every restoration project conducted at the FEMP. Construction and maintenance personnel apply a latex-based repellent on all foliage accessible to deer browsing. In general, browsing vulnerability is limited to shrubs and seedlings, since the foliage of most sapling trees is out of reach to deer. Repellent application is labor-intensive. Personnel must apply the repellent to each plant individually, using a hand sprayer. Up to three applications per year are required in order to account for new growth and wash-off from precipitation. To date, repellents have seemed effective in the A1PI Ecological Restoration Park and the A8PII Forest Demonstration Project. However, it is impossible to determine whether the light browsing activity within these areas is due to the effectiveness of repellents or because deer densities are lighter. In the A1PI Wetland Mitigation Project, the effectiveness of repellents appears to be somewhat limited. As outlined in Section 2.2.5, deer browsing in the wetland impacted a large number of trees and shrubs within the area, despite repeated applications of deer repellent.

Odor repellents, in the form of garlic sticks, have been used in A8PII and in A1PI. It is impossible to determine the effectiveness of these repellents, since they have only been used in conjunction with taste repellents. The sticks must be replaced when they lose potency.

3.2 PROTECTIVE TUBING

The primary preventative measure for deer rubbing damage is the use of protective tubing. Originally, heavy-gauge, black plastic drain tubing was used to protect trees on site, but it proved difficult to work with. Its heavy gauge often damaged sapling trunks during installation, and the tubes had to be removed each summer to avoid heat stress on the plants. A lighter-gauge plastic tubing was consequently used that allowed easier installation and year-round protection. Virtually all planted saplings were fitted with protective tubing across the site in Fall 2000.

Comparison of data within A8PI indicate that the use of protective tubes do significantly lower the extent of deer rubbing. Trees that were protected in 1999 as part of the Ecological Restoration Park fared much better than the adjacent saplings planted in the revegetation research plots, which did not have tubes installed at the time. Most of the trees that were impacted within the Ecological Restoration Park were saplings that could not be protected with tubes, such as red cedar and low-branching flowering dogwood. Similar findings were observed within A8PII. The Fall 2000 deer impact survey revealed that out of the 106 trees that were rubbed or destroyed, 13 did not have tubes on them. (About 15 trees did not receive tubes, because they were either already dead or were missed.) There were several instances where a tube was ripped off of the trunk of the tree or pushed down to expose the trunk. However, most of the Fall 2000 damage in A8PII occurred when deer broke off limbs that were located above the tubing.

3.3 EXCLOSURE FENCING

As stated above, exclosure fencing was not acceptable in A1PI. However, as part of research on restoration of the American chestnut, a small (0.25-acre) research plot in A8PI has been enclosed with fencing. An 8-foot, plastic mesh fence was originally installed around the American Chestnut plot in 1999. The fence proved ineffective in preventing deer from entering the chestnut plot, and most of the research seedlings were subsequently browsed. The fence was replaced in 2001 with a 10-foot, woven wire fence that appears to be effective in keeping deer out of the plot. There have been no other deer controls employed at the FEMP to date.

4.0 OPTIONS FOR FUTURE CONTROL

As stated in Section 1.2, the cultural carrying capacity of deer at the FEMP is probably exceeded. Ecological restoration projects must be protected from browsing and rubbing pressure by site deer. Efforts so far have primarily been limited to the use of repellents and protective tubing. A variety of other options are available. This section summarizes some additional approaches that may be undertaken to ensure success of ecological restoration at the FEMP.

4.1 REDUCING DEER POPULATION

A reduction of the site deer population is one means of lessening browse and rub pressure. Several options to accomplishing this are summarized below.

4.1.1 Hunting On-Property

Regulated hunting has been proven to be an effective management tool in managing deer populations. It is also the most efficient and the least expensive technique for removing deer. Wildlife management agencies recognize deer hunting as the only effective, practical, and flexible method available for regional deer population management, and therefore rely on it as their primary management tool. Through the use of regulated hunting, deer populations may be maintained at desirable levels by manipulating the size and sex composition of the population; the hunting season type, timing, and length; the number of permits issued; and land-access policies issued. Concerns with using regulated hunting include the noise factor from shotgun blasts, the possibility that wounded deer may travel onto private property, and the potential for other liability issues to arise. Site personnel do access remote areas of the site on a regular basis for surveying, sampling, and monitoring activities, making hunting on the FEMP an undesirable option for controlling deer. Another consideration is that any reduction in the number of deer on-property may be quickly offset by other deer accessing the property due to the excessive number of deer in surrounding areas and in both Hamilton and Butler Counties.

4.1.2 Sharpshooters

The use of sharpshooters may be an effective method of reducing deer populations. Employing qualified sharpshooters on governmental properties may address safety, public relations, and other liability concerns. The use of sharpshooters to reduce deer populations has increased significantly in the last decade.

Costs associated with sharpshooter operations are typically high. To be effective, qualified shooters with proper equipment must have ready access to deer which means that deer will have to be baited to a given area. Costs would be incurred for bait, shooter salaries, and expenses for processing the animal. Estimated costs per deer removal using this method are $91 to $260.

The use of sharpshooters may be an effective tool in reducing the deer population on the site in the short-term. Problems associated with the alternative include perception issues associated with shooting a large number of deer at the site, logistics of getting the deer either processed for meat or disposed of properly and safety issues due to the proximity of adjacent landowners. The use of sharpshooters is not considered to be a feasible option at the FEMP.

4.2 FENCING

Fences create a barrier between deer and the protected vegetation. In situations where deer pressure is moderate to high, and/or the value of the vegetation is high, physically excluding deer from the growing areas using fencing may be necessary. An effective deer fence may be an 8-foot tall barrier or smaller, electric system. Barrier fences are more costly than electric ones. However, electric fences are inappropriate where high human contact is likely. Regular inspection and maintenance of fences increase their effectiveness. Grass, tree limbs, and other debris should not be touching the fence, otherwise the power from the battery will be reduced. Grass should be kept short or the area under the fence should be mulched to prevent vegetation from touching the fence.

Electric fencing is an ideal solution to keep out deer. It is more effective than physical barriers or chemical repellents because it instills the fear of being shocked into the animals. Once the electric fence is in place, animals will avoid the fence and search elsewhere for food. The fence delivers a quick shock and frightens the animal, but will not harm it.

The cost of an effective fence may pay for itself over a few years. Labor and material costs (excluding chargers) vary from $0.10 per linear foot for a single strand of polywire electric fence to $6 per linear foot for a woven wire fence. An estimate for materials for a 10-acre area is about $750 to $800.

Another fencing alternative is installing exclosure fences around individual trees and shrubs. This would involve installing a piece of woven wire fence around a tree, held in place with either t-posts or stakes at

the bottom of the fence to protect that individual tree. This may be feasible on a limited basis in areas where intense deer rubbing or browsing occurs, but will not be practical on a large scale due to the number of trees and shrubs in restored areas.

4.3 RELOCATION OF DEER

Deer may be relocated using traps, netting, or immobilization for the purpose of capturing and relocating deer. This process would be labor intensive and would require transporting the deer to sites able to accept large numbers of them.

Relocating deer is not practical for large herds, but are valuable in controlling small populations. This technique may be labor intensive and therefore be expensive. Research estimates in other areas indicate the cost varies between $431 and $800 per deer.

4.4 FURNISHING ADDITIONAL FOOD TO REDUCE DEER BROWSE

Providing supplemental food may reduce the damage to valuable planted vegetation. The theory is that deer will eat this supplemental food instead of browsing on vegetation. Likewise, the planting of buffer crops may also be an effective technique to direct deer away from the planted species. However, increasing the food source may compound the problem of deer overpopulation. Supplemental food may be useful for temporary relief from deer browse, but will not provide a long-term solution.

5.0 RECOMMENDED PATH FORWARD

Restored Areas will require protection throughout the restoration process to ensure the successful establishment of planted trees and shrubs. Clearly the options of exclusion fencing and on-property culling of the deer herd will not be feasible at the FEMP due to ongoing site activities and perception issues of local stakeholders. Fluor Fernald, Inc. proposes the following four-tiered approach to minimize the impacts of deer to restored areas of the FEMP.

5.1 CONTINUED USE OF TREE TUBES AND REPELLENTS

DOE will continue using tree tubes and repellents to deter deer from browsing and rubbing planted trees and shrubs. Repellent sprays will continue to be applied two or three times per year, depending on the manufacturer's specifications. Tree tubes will be placed on all newly planted stock (where feasible) and existing tree tubes will be maintained in all restored areas to minimize further damage.

5.2 USE OF SYSTEMIC REPELLENTS

Fertilizer tablets containing a systemic repellent will be utilized on a trial basis in Spring 2002. The tablets are placed in the soil at the base of the trees or shrubs and provide both a fertilizer and a repellent that is absorbed by the tree or shrub. The repellent is then given off in the odor of the plant and has been shown to repel deer and other creatures. If systemic repellents prove to by effective, they will be used on a more widespread basis in restored areas.

5.3 OFF-PROPERTY DEPREDATION PERMITS

Support should be provided to local landowners that are interested in obtaining depredation permits to reduce deer impacts on their property. DOE has received feedback from many landowners around FEMP regarding the number of deer moving on and off of the property. Any reduction in the number of deer on adjacent property should only benefit the restoration effort on the FEMP since most deer are believed to be moving on and off of the property. DOE has already met with adjacent landowners and game wardens for Hamilton and Butler Counties to discuss depredation permits and Fluor Fernald supports this effort.

5.4 USE OF ELECTRIC FENCE

The experimental use of an electric fence, generated from either a solar power or from an electric source, adjacent to a restored area should also be utilized on a trial basis to determine its effectiveness. Electric fence kits can be acquired for a very reasonable price and are relatively easy to install. If they are effective, they may be an option for larger restored areas. The fence that Fluor Fernald is proposing for use is one that would bait the deer to approach the fence and then administer a mild shock to deter it from approaching the area again. A portion of the wetland mitigation project, a portion of A8PII or the Southern Waste Units (once restored) would be ideal locations for testing this type of fence.

5.5 EVALUATION AND REPORTING

Implementation of the approaches described above should reduce the extent of deer impacts to restored areas at the FEMP. To assist in oversight and evaluation of the FEMP deer population, DOE proposes to consult with a local deer management expert. This individual will advise DOE and Fluor Fernald regarding the status of the FEMP deer population and the effectiveness of the path forward. Management activities, their effectiveness, and future recommendations will be summarized for each project and reported annually as part of the Consolidated Monitoring Report for Restored Areas at the FEMP.

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TABLE 1
SUMMARY OF DEER DAMAGE AND CONTROL MEASURES AT THE FEMP

	1999					2000					2001				
Project	dead	damaged	tube	repellant	garlic stick	dead	damaged	tube	repellant	garlic stick	dead	damaged	tube	repellent	Garlic stick
A8PIa	17%	39%				7%	11%	✓			14%	31%	✓		
A8PIb	4%	6%	✓			--	--	✓	✓		--	--		✓	
A2PI	10%	58%				--	--	✓			--	--	✓		
A1PII	--	--				--	54%	✓	✓		--	35%	✓	✓	
A1PI	--	--				17%	39%	✓	✓	✓	5%	27%	✓	✓	
A8PII	--	--				2%	7%	✓	✓	✓	1%	6%	✓	✓	

A8PIa - Miami University Research Plots
A8PIb - Ecological Restoration Park
A2PI - Bioengineering Project
A1PII - Aesthetic Barrier Project (deciduous trees)
A1PI - Wetland Mitigation Project
A8PII - Ecological Restoration Project

TABLE 2
SUMMARY OF DEER DAMAGE BY PATCH IN AREA 1, PHASE I

Patch	No.	%	Patch	No.	%	Patch	No.	%	Patch	No.	%
WS17	65	51	WS10	15	32	WS15	8	32	UF6	3	14
WS19	43	41	US7	14	52	US14	7	21	UF16	3	38
WS9	41	30	US11	14	33	US15	7	54	US6	3	33
WS23	36	65	US21	14	36	US16	7	29	WF7	3	9
US13	29	73	US23	14	45	US26	7	23	WF8	3	11
US30	28	64	US27	14	30	WF4	7	17	UF1	2	18
WS4	28	25	WS1	14	58	US5	6	38	UF2	2	20
WS6	27	100	US8	13	43	WS3	6	22	UF10	2	18
WS7	26	100	US17	13	28	WS16	6	15	WS13	2	5
US29	25	52	US28	13	14	UF3	5	21	UF5	1	5
WS18	23	61	WS24	13	25	UF8	5	21	WF1	1	5
US20	22	41	UF14	12	27	US1	5	38	WF2	0	0
US22	22	47	US12	12	40	US2	5	39	WF3	0	0
WS27	22	49	WS11	12	86	US4	5	42	WF5	0	0
US32	21	55	WS25	12	43	WS14	5	14	WS5	0	0
WS20	19	63	UF7	11	25	UF4	4	25	WS8	0	0
US3	18	36	US33	10	43	UF15	4	20	WS12	0	0
US25	18	40	UF11	9	14	US9	4	67	WS21	0	0
UF13	17	55	US18	9	13	US10	4	100	WS22	0	0
UF9	16	18	US24	9	47	WF6	4	24	WS26	0	0
UF12	16	41	US19	8	44	WF10	4	6			
US31	16	100	WF9	8	28	WS2	4	24			

WF – Wetland Forest
WS – Wetland Shrub
UF – Upland Forest
US – Upland Shrub

TABLE 3
SUMMARY OF DEER DAMAGE BY SPECIES IN AREA 1, PHASE I

Species	Common Name	Damage	Dead	Total
Cornus amomum	silky dogwood	101	9	110
Rosa palustris	swamp rose	58	11	69
Sambucus canadensis	American elder	35	15	50
Viburnum dentatum	arrow-wood	40	4	44
Alnus serrualta	brook-side alder	30	11	41
Ilex verticillata	common winterberry	39	--	39
Rhus typhina	staghorn sumac	22	17	39
Cornus racemosa	gray dogwood	32	7	39
Aronia melanocarpa	black chokecherry	38	--	38
Prunus virginiana	choke cherry	31	7	38
Salix discolor	pussy willow	26	11	37
Amelanchier laevis	Allegheny serviceberry	35	1	36
Hamamelis virginiana	American witch-hazel	23	4	27
Lindera benzoin	northern spicebush	26	1	27
Rhus glabra	smooth sumac	24	1	25
Rosa setigera	prairie rose	17	4	21
Staphylea trifolia	American blatternut	19	--	19
Quercus bicolor	swamp white oak	14	5	19
Salix exigua	sandbar willow	17	--	17
Cornus alternifolia	alternate-leaf dogwood	10	6	16
Juglans nigra	black walnut	13	3	16
Rubus occidentalis	black raspberry	13	--	13
Viburnum acerifolium	maple-leaf speedwell	9	4	13
Diospyros virginiana	common persimmon	11	--	11
Corylus americana	American hazel-nut	10	--	10
Rubus allegheniensis	Allegheny blackberry	10	--	10
Cephalanthus occidentalis	common buttonbush	7	2	9
Physocarpus opulifolius	eastern ninebark	9	--	9
Tilia americana	American basswood	4	5	9
Ulmus rubra	slippery elm	--	9	9
Campsis radicans	trumpet creeper	7	--	7
Zanthoxylum americanum	prickly ash	5	2	7
Quercus velotina	black oak	4	3	7
Crateagus mollis	downy hawthorn	6	--	6
Lonicera sempervirens	trumpet honeysuckle	6	--	6
Celtis occidentalis	common hackberry	6	--	6
Viburnum prunifolium	black-haw	4	1	5
Gymnocladus diocia	Kentucky coffee-tree	3	2	5
Prunus serotina	black cherry	3	2	5
Rosa carolina	Carolina rose	3	1	4
Aesculus glabra	Ohio buckeye	3	1	4

TABLE 3
SUMMARY OF DEER DAMAGE BY SPECIES IN AREA 1, PHASE I
(Continued)

Species	Common Name	Damage	Dead	Total
Prunus americana	American plum	1	3	4
Quercus imbricaria	shingle oak	4	--	4
Quercus macrocarpa	bur oak	4	--	4
Hibiscus muscheutos	swamp rosemallow	3	--	3
Acer rubrum	red maple	--	3	3
Asimina triloba	common paw-paw	--	3	3
Fagus grandifolia	American beech	1	2	3
Quercus coccinea	scarlet oak	3	--	3
Quercus palustris	pin oak	3	--	3
Sassafras albidium	sassafras	2	1	3
Celastrus scandens	American bitter-sweet	2	--	2
Salix eriocephala	Missouri River willow	2	--	2
Salix sericea	silky willow	2	--	2
Spiraea tomentosa	steeple-bush	2	--	2
Fraxinus americana	white ash	2	--	2
Ostrya virginiana	eastern hop-hornbeam	2	--	2
Quercus shumardii	shumard oak	2	--	2
Parthenocissus quinquefolia	Virginia creeper	1	1	2
Amelanchier arborea	downy serviceberry	1	--	1
Crateagus crusgalli	cockspur hawthorn	1	--	1
Hydrangea arborescens	wild hydrangea	1	--	1
Ribes americanum	wild black currant	1	--	1
Acer saccharum	sugar maple	1	--	1
Fraxinus nigra	black ash	1	--	1
Liquidambar styraciflua	sweet gum	1	--	1
Liriodendron tulipifera	tulip tree	--	1	1
Quercus alba	white oak	1	--	1
Quercus rubra	northern red oak	1	--	1
Ulmus americana	American elm	--	1	1
Totals		***818***	***164***	***982***

TABLE 4
SUMMARY OF DEER DAMAGE BY PATCH IN AREA 8, PHASE II

Location	Total Species Planted	Total Species with Deer Damage	Total Species that Survived	Survival Rate (%)	Species with Deer Damage (%)
RP1	30	--	25	83.33	--
RP2	106	4	87	82.08	3.77
RP3	43	4	27	62.79	9.30
RP4	16	12	7	43.75	75.00
RP5	46	2	41	89.13	4.35
MM8	67	4	62	92.54	5.97
MM9	48	--	42	87.50	--
MM10	79	1	67	84.81	1.27
MM11	49	2	43	87.76	4.08
MM12	64	6	55	85.94	9.38
MM13	50	1	40	80.00	2.00
MM14	70	4	58	82.86	5.71
MM19	64	8	54	84.38	12.50
MM20	40	4	33	82.50	10.00
MM21	74	17	60	81.08	22.97
MM22	48	17	35	72.92	35.42
BS23	70	2	63	90.00	2.86
BS24	42	2	35	83.33	4.76
BS25	75	3	62	82.67	4.00
BS26	38	2	31	81.58	5.26
BS27	63	3	54	85.71	4.76
BS28	35	5	30	85.71	14.29
BS29	50	8	41	82.00	16.00
BS30	36	2	27	75.00	5.56
OS1	69	1	49	71.01	1.45
OS2	62	--	51	82.26	--
OS3	79	2	66	83.54	2.53
OS4	58	--	49	84.48	--
SV1	12	--	7	58.33	--
SV2	16	--	8	50.00	--
SV3	16	--	4	25.00	--
SV4	18	--	14	77.78	--
SV5	10	--	6	60.00	--
SV6	22	--	13	59.09	--
SV7	22	2	11	50.00	9.09
SV8	13	--	10	76.92	--
SV9	16	1	9	56.25	6.25
SV10	13	--	4	30.77	--
BF31	65	4	50	76.92	6.15
Totals	***1794***	***123***	***1430***	***80%***	***7%***

TABLE 5
SUMMARY OF DEER DAMAGE BY SPECIES IN AREA 8, PHASE II

Scientific Name	Common Name	Type	Size	Deer Damage	Total Spp. Planted	% Spp. Affected by Deer Damage
Cornus drumondii	roughleaf dogwood	tree	1.5" cal.	2	4	50.00
Quercus muhlenbergii	chinquapin oak	tree	1.5" cal.	1	2	50.00
Rhus glabra	smooth sumac	shrub	1 gal.	7	18	38.89
Cornus florida	flowering dogwood	tree	1.5" cal.	4	11	36.36
Liquidambar styraciflua	sweetgum	tree	1.5" cal.	1	3	33.33
Ostrya virginiana	hop hornbeam	tree	1.5" cal.	1	3	33.33
Tilia americana	American basswood	tree	1.5" cal.	31	112	27.68
Liriodendron tulipifera	tulip poplar	tree	1.5" cal.	7	27	25.93
Quercus shumardii	Shumard oak	tree	1.5" cal.	1	4	25.00
Cercis canadensis	redbud	tree	1.5" cal.	3	13	23.08
Ilex veticallata	winterberry	shrub	2-3'	3	17	17.65
Quercus bicolor	swamp white oak	tree	1.5" cal.	2	13	15.38
Sambucus canadensis	elder	shrub	1 gal.	2	13	15.38
Aesculus octandra	yellow buckeye	tree	1.5" cal.	9	62	14.52
Carya ovata	shagbark hickory	tree	1.5" cal.	3	21	14.29
Hamamelis virginica	witch-hazel	shrub	1 gal.	3	23	13.04
Staphylea trifolia	bladdernut	shrub	1 gal.	3	30	10.00
Prunus serotina	black cherry	tree	1.5" cal.	3	34	8.82
Fagus grandifolia	American beech	tree	1.5" cal.	14	205	6.83
Fraxinus pennsylvanicum	green ash	tree	1.5" cal.	4	60	6.67
Salix amygdaloides	peach-leaf willow	tree	3-4'	1	15	6.67
Viburnum prunifolium	black-haw viburnum	shrub	1 gal.	1	16	6.25
Hypericum spathulatum	shrubby St. John's wort	shrub	2-3'	2	33	6.06
Platanus occidentalis	sycamore	tree	1.5" cal.	1	19	5.26
Rhus aromatica	staghorn sumac	shrub	3'	1	20	5.00
Ceanothus americanus	New Jersey tea	shrub	1 gal.	1	24	4.17
Quercus palustris	pin oak	tree	1.5" cal.	1	26	3.85
Acer saccharum	sugar maple	tree	1.5" cal.	4	119	3.36
Cornus racemosa	grey dogwood	tree	1.5" cal.	1	30	3.33
Juglans nigra	black walnut	tree	1.5" cal.	1	30	3.33
Quercus rubra	red oak	tree	1.5" cal.	1	32	3.13
Quercus alba	white oak	tree	1.5" cal.	1	38	2.63
Corylus americana	hazel	shrub	1 gal.	1	46	2.17

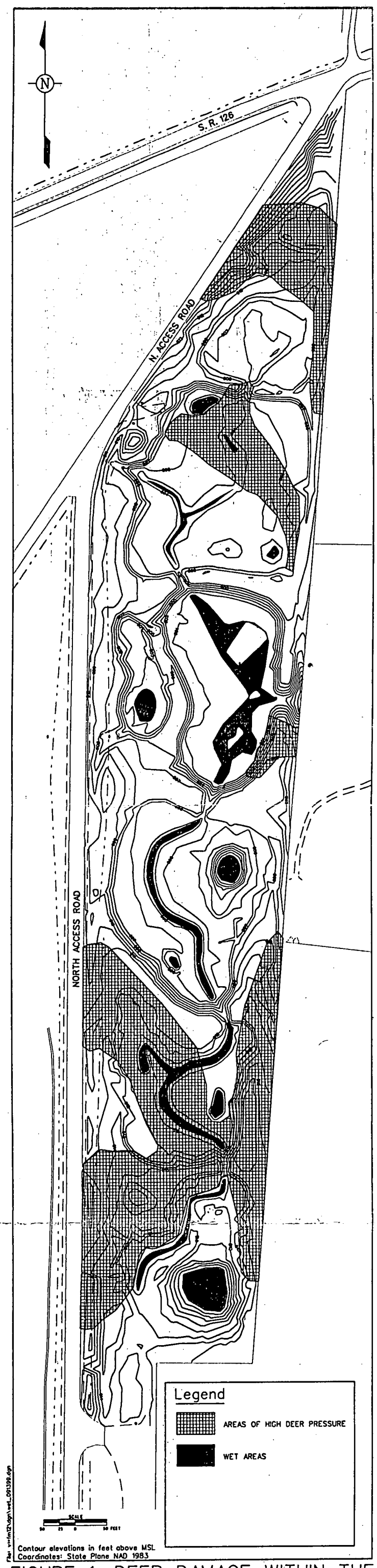

FIGURE 1. DEER DAMAGE WITHIN THE A1PI WETLAND MITIGATION PROJECT

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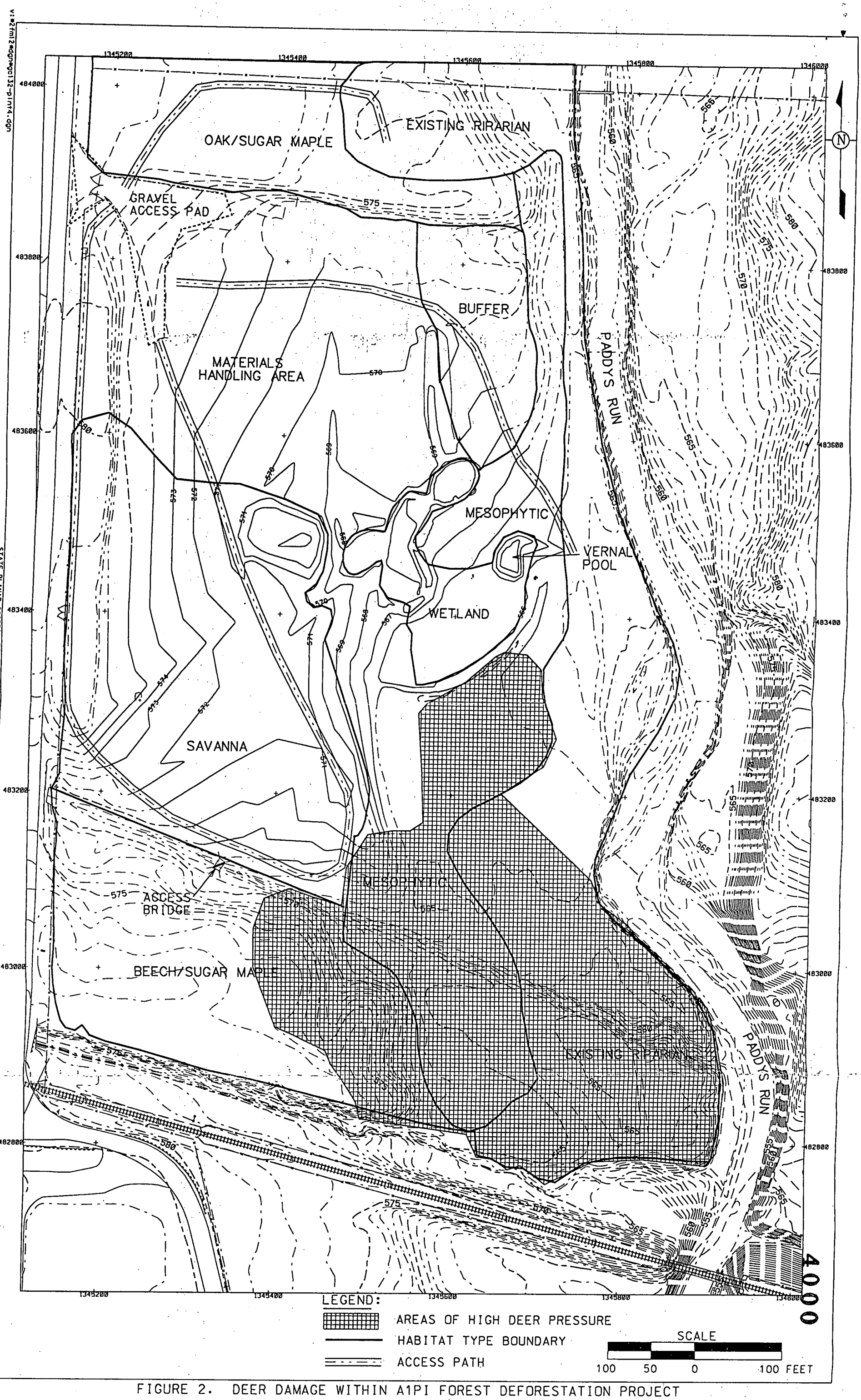

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FIGURE 2. DEER DAMAGE WITHIN A1PI FOREST DEFORESTATION PROJECT